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American Potato Journal

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POTATO BREEDING, GENETICS, AND CYTOLOGY: REVIEW OF LITERATURE OF INTEREST TO POTATO BREEDERS[1]

F. J. STEVENSON[2]

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The literature indicates a wealth of material, species, and varieties, available to the potato breeder. Excellent work is being done by the British in studying the classification and cytology of their South American potato collection, but no comparable work is being done in the United States, although there is great need for it.

Progress is shown in breeding for resistance to important virus and fungus diseases.

Since the golden nematode has become such a menace to potato growing in a section of Long Island, the possibility of producing varieties resistant or tolerant to its attacks has been discussed. It has been the general impression that all varieties and species tested were susceptible, but Ellenby's (*10*) article indicates that some species are far less susceptible than others. In some cases a species was classed as susceptible on the basis of a single cyst on its roots. Giant hills, or "bolters"

[1]Some of the material in this report, especially that concerning articles written in foreign languages, was taken from the abstracts published by the Imperial Bureau of Plant Genetics, Cambridge, England.

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as they are called in England, have been observed in the United States for many years. Thomas (*35*) stated that they are characterized by the presence of a small additional chromosome fragment.

The remarkable influence of stock on scion is shown by several Russian workers.

Blackening after cooking is a genetic character conditioned by genes but influenced by environment.

Much interest is being shown in ascorbic acid content. Factors that determine the amount of ascorbic acid in the finished food product include variety, seasonal and other environmental conditions, state of maturity, storage temperatures, and cooking methods.

A relatively large number of varieties have been described within the last three years.

Breeding Methods

Krantz (*22*) reported investigations on potato breeding based on what he considers the relationships between flowering, fruit development, and tuber production.

Breeding Program

Stevenson (*34*) gave a brief account of the early improvement of the potato in the United States, the work that is being carried on at present under the National Potato-Breeding Program, and some of the possibilities for the future.

Breeding Material

Hawkes (*16*) described the values to the breeder of some of the indigenous American potatoes.

Solanum demissum is valuable because of its resistance to blight, Colorado beetles, and frost, and because of its fertility when selfed and crossed with the tetraploids *S. andigenum* and *S. tuberosum*. *S. andigenum*, the most promising cultivated species, contributes high vigor, yield, protein, vitamin C, and starch content, together with a greater range of flavor and cooking qualities than that of the ordinary European domestic potato. It is highly fertile. In problems that have hardly been touched, such as resistance to nematodes, the need for a thorough survey of the indigenous American potatoes was emphasized.

Classification and Cytology

Hudson (*17*) reported that the classification and cytology of the South American potato collection was almost completed. *Solanum ajuscoense, S. antipovichii, S. calcense, S. garciae jamesii,* and many

samples among *S. andigenum* showed promise of resistance to virus diseases. Some clones were found resistant or immune to blight. Nearly 1,500 lines were tested for frost resistance, and 216 lines showed resistance. Some lines appeared to be immune or highly resistant to eelworm attack.

Cytogenetics

Lamm (*23*) reported the results of cytogenetic studies in a number of species of *Solanum* by means of cytological investigation, interspecific hybrids, and colchicine-induced polyploids. *Solanum curtilobum* (pentaploid) as maternal parent crosses readily with *S. tuberosum* and *S. andigenum;* the first-generation hybrids are comparatively fertile. The reciprocal cross is difficult to achieve but was obtained by grafting the maternal parent on tomato. First-generation hybrids of this cross are male-sterile.

Meiosis in the first cross is normal; in the reciprocal abnormal. Hybridization between *Solanum acaule* and *S. tuberosum* failed. After chromosome doubling in *S. acaule* hybrids were easily obtained, *S. acaule* being used as female parent. The first generations of the hexoploid and near hexaploid are fertile. In the case of the tetraploid species it is suggested that *S. tuberosum* is mainly an autotetraploid but in comparison with the true colchicine-induced autotetraploids investigated, shows differentiation in the direction of allotetraploidy. *S. acaule* and *S. tuberosum* appear to be related tetraploids.

Genetics of Tuber Color

Carson and Howard (*6*) stated that the variety King Edward is simplex for the gene K, determining pink periderm coloration, and is multiplex for gene K which induces pink cortical pigmentation. A converse arrangement was found for the variety Flourball.

Genetic Leaf Roll

LeClerg (*25*) reported a leaf roll of small potato seedlings grown from true seed in 3-inch pots in the greenhouse at Baton Rouge, Louisiana, during the winter of 1943. This was shown to be genetic since it occurred in some family lines and not in others. Stem-graft inoculations with the rolled plants on disease-free stocks all gave negative results, which indicated that the rolling was not due to virus. None of the plants grown in the field from tubers produced in the greenhouse showed any type of leaf rolling during the growing season.

Virus Resistance

Feistritzer (*11*) gave a detailed description of the difficulties of breeding potatoes resistant to leaf roll; to viruses A, Z, and Y; or to

mixed infections. Since complete immunity to the severe degeneration diseases has not been found, the present aims of a breeding program should be discovering and producing types more resistant than the most resistant known varieties. Several selections from crosses of varieties whose resistance was recognized by growers, were found to be equal to the parent in resistance, and at least two of them were more resistant. The difficult problem of combining increased resistance with good table quality was brought out, since a large number of factors must be combined to ensure a combination of these two characters in a high degree.

Resistance to Virus Leaf Roll

Folsom and Stevenson (*12*) reported the results of a number of tests of seedlings and varieties for their reactions to field spread of leaf roll. These were grown adjacent to rows of leaf roll plants in an area where the disease spreads consistently year after year. At first, American varieties and European varieties reputed to be resistant to leaf roll were used as parents, and a few of the crosses contained some seedlings resistant to the natural spread of leaf roll. When these resistant seedlings were used as parents the resulting progeny showed more resistance. It is possible to combine field resistance to leaf roll with many characters of commercial importance.

McKay and Clinch (*26*) reported a high degree of resistance to leaf roll in Skerry Champion. It showed about 1 per cent infection while Matador and Shamrock showed 8 per cent.

Resistance to Virus Y

Badwin and Kassanis (*2*) reported that the American variety Katahdin showed the highest degree of resistance to virus Y among the varieties tested. Various degrees of resistance were found among the commercial English varieties. Relative susceptibility in field tests was found to be correlated with susceptibility when colonized with infective aphids. Susceptibility to virus Y and to leaf roll are independent.

Hutton and Bald (*19*) reported that in an attempt to breed hybrid potatoes resistant to virus Y the development of a necrotic reaction to the condition of hypersensitivity seems to be more promising than breeding for immunity. Hypersensitive seedlings were selected from the crosses Snowflake x Katahdin and Brown's River x Katahdin.

Hutton (*18*) reported further that once hypersensitive types have been selected in the hybrid progeny, crosses involving them produce 10 to 30 per cent of hypersensitive seedlings. As breeding sources of hypersensitivity the varieties Snowflake, Katahdin, and Brown's River have been found to be more promising than Bismark, Delaware, Factor, and

Sebago. The hypersensitive reaction to virus Y appears to depend on one or more recessive alleles, tolerance to the virus being dominant.

Severe Strains of Virus X

Fred (*13*) of the Wisconsin Agricultural Experiment Station reported work done by Larson from which he learned that severe strains of latent potato viruses commonly are associated with low-yielding lines of potatoes, whereas mild latent viruses generally are found in the higher-yielding potatoes.

Resistance to Late Blight

Black (*3*) reported on the inheritance of reaction to the common A strain of blight in a triple hybrid (*Solanum rybinii* x *S. demissum*) x *S. tuberosum* and from a multiple hybrid W 800 (*2*) in which five species, *S. commersonii, S. maglia, S. edinense, S. demissum,* and *S. tuberosum* were involved in the pedigree. The results suggest that the primary reaction of resistance and susceptibility to blight depends upon two major genes Ra and Rb, and that minor genes determine the degree of susceptibility in susceptible varieties and act as modifiers in resistant varieties. In general, the segregations of resistant and susceptible plants do not fit the ratios 1:1, 3:1, or 15:1, a consistent excess of recessives being shown.

Physiologic Races of Scab

Schaal (*33*) found that single-spore cultures of scab (*Actinomyces scabies*) obtained from potatoes grown on various soil types in different states differed in color of mycelium and of pigment produced on modified potato-dextrose agar. The isolates were unstable and produced variants that were often culturally different from the parents and from each other. A number of isolates tested on three commercial and five seedling varieties of potatoes different in pathogenicity. Certain strains produced russeting of normally smooth-skin varieties.

Wart Resistance

Hartman and Akeley (*15*) reported that the potato wart is still confined to restricted areas in Pennsylvania from which state it was first reported. Its spread has been controlled by temperature and moisture relationships, by immune varieties, and by strict quarantine regulations. So far there is no evidence of new biotypes in the United States, but there is no assurance that new forms having greater virulence and a wider range of adaptation will not be found. Of fourteen new American varieties Katahdin, Mohawk, Sequoia, Mesaba, and

Norkota are immune. Two selfed lines of Katahdin showed after grouping about fifty per cent of their seedlings to be very resistant to wart.

Verticillium Resistance

Mujica (*27*) established the existence of different races of *Verticillium albo-atrum*. Irish Cobbler was susceptible, and Katahdin proved immune.

Brown Spot

Fred (*13*) of the Wisconsin Agricultural Experiment Station reported work done by Larson the results of which indicated that the newest potato varieties, like standard ones, differ markedly in their susceptibility to what is variously known as internal brown spot or nonparasitic tuber necrosis. Least susceptible were Triumph, Pontiac, and Red Warba; intermediate, Chippewa, Sebago, Sequoia, Russet Burbank, and White Rose; most susceptible, Russet Rural, Rural New Yorker, Katahdin, and Green Mountain.

Resistance to Aphids

Adams (*1*) pointed out the desirability of breeding a commercially acceptable potato variety whose aphid resistance would be substantial enough to limit the spread of aphid-borne viruses in the crop. A considerable number of American and European varieties and a number of species were tested for their reactions to aphids. Two criteria were used in classifying the varieties: aphid population build-up and plant injury. The varieties were placed in five classes; very susceptible, susceptible, tolerant, resistant, and very resistant. Katahdin and U. S. D. A. Seedling 41956 were very susceptible showing peak population of 35,000 aphids. The plants of these two varieties were dead six weeks after the establishment of the aphid colonies. Chippewa, Irish Cobbler, Triumph, Sebago, and Pontiac were susceptible; Green Mountain, President, Warba, Arran Victory, and *Solanum chacoense* were tolerant; Fredericton Seedling 996-1-4, Houma, Earlaine, Sequoia, *S. demissum, S. commersonii,* and *S. chacoense* were very resistant; and *S. polyadenium* seemed to be immune. A similarity between results obtained in leafhopper resistance studies and those found in aphid studies is noted.

Nematode Resistance

Ellenby (*10*) tested a number of species and varieties from the Empire Potato Collection for their reaction to golden nematode. Nearly forty South American species showed susceptibility to eelworm attack when grown in soils infested with cysts. Most of the plants of the species tested appeared to be less susceptible than the *S. tuberosum* variety Great

Scott. Fewer cysts were formed and in some cases a species was classed as susceptible on the basis of a single cyst on its roots; in addition, the cysts were often more immature than the cysts on the roots of the control.

Mutations

Thomas (*35*) reported that "bolter" forms of the varieties Gladstone, Doon Star, and Majestic are characterized by the presence of a small additional chromosome fragment.

Grafts

Glushchenko (*14*) reported that by propagating from the adventitious buds on various potato varieties white or yellow progenies were obtained from colored parents. In the progeny of the variety Zarnica vegetative segregation occurred. Different tubers on the same plant showed different colors. Variations of a similar kind were observed in other characters. The existence of genetic differences in different plant tissues was given as the explanation.

Turlapova (*36*) described the development of an early industrial variety of potato by grafting. In 1939, 600 grafts were made of starchy varieties, such as Wohltmann and Korenevskii on the Early Rose. Of the grafts eighty-seven per cent were successful. The influence of stock on scion was observed in the flower color and in the form and color of the tubers. Three selections were made which exceeded the Early Rose in yield and starch content. The new hybrids were a few days later than Early Rose in maturity but the tubers reached the maximum starch content earlier than Early Rose.

Tushniakova (*37*) reported that a potato grafted on *Datura inermis* Jacq., for example, contained 0.3 per cent of atropine. It formed aerial tubers, and these when planted gave rise to plants that contained up to 0.15 per cent of atropine in their leaves, stems, and tubers. In 1942, among the progeny of Bison tomato grafted on potato, one plant was found that produced three small tubers on its roots; from them three abnormal potato plants were produced, which formed a mass of aerial tubers on their stems, together with a number of small underground tubers. Both aerial and underground tubers were planted and gave rise to the same type of plants as their parents.

Blackening after Cooking

Rieman *et al.* (*32*) found consistent differences in amounts of blackening after boiling among 23 potato varieties and strains grown over a period of five years at 9 widely separated locations in Wisconsin. The two whitest-cooking varieties, Triumph and Chippewa, showed

only one-half as much blackening as the two dark-cooking varieties, Rural New Yorker and Russet Rural. The white-cooking tendencies shown by the closely related Chippewa, Katahdin, and Sebago suggest that these carry genetic factors for white tuber flesh after boiling. Results from certain crosses indicated that white tuber flesh after cooking was dominant or incompletely dominant to gray tuber flesh. Parental types were readily recovered in the first generation, indicating simple factorial interactions and heterozygosis in the parental stocks.

Ascorbic Acid Content

Werner and Leverton (*38*) examined more than 5,000 tubers over a period of three years for ascorbic acid content. The ascorbic acid content differs with varieties. Growing conditions, stage of maturity at harvest time, and storage temperatures cause variability within the variety. Potatoes harvested at practically the same stage of maturity in three different years differed greatly in ascorbic acid content. Ascorbic acid seems to increase in the tubers until the vines reach maximum growth, and as the vines mature the ascorbic acid content of the tubers decreases. Potatoes grown on dry land generally have a greater amount of ascorbic acid than those grown under irrigation. Potatoes lose ascorbic acid at a relatively constant rate during storage but they lose the least when stored at temperatures between 50° and 70° F. Potatoes cooked carefully in very little water and tight-fitting kettle lids lose as little as five per cent of their ascorbic acid, but boiled vigorously in a large amount of water they may lose as high as twenty per cent or more.

Murphy (*28*) stated that when cabbage, collards, broccoli, kohlrabi, turnips, tomatoes, and potatoes were compared for vitamin C content potatoes ranked sixth, but when the same values are calculated according to appetite level the potato ranks first. Loss of vitamin C in storage is related to variety and temperature. Irish Cobbler, Green Mountain, Mohawk, Chippewa, Katahdin, and Sebago were held at temperatures of 32°, 36°, 50°, 60° or 65° and 70° F. for seven months in two successive seasons. Tubers were analyzed for vitamin C at monthly intervals. Mohawk showed a relatively high vitamin C content when freshly dug and remained at a relatively high level. Chippewa was low throughout the entire period. Sebago decreased at a disproportionately rapid rate, but Green Mountain tended to improve its position. In general, varietal differences diminished greatly under the influence of storage but were not completely nullified. If vitamin C retention is a criterion of quality 50° F. would be the best temperature tested.

Lampitt *et al.* (*24*) found that variety, soil, and storage affected

the vitamin C content of the potato. Samples were taken from four widely scattered areas in England and Scotland. Comparison between freshly dug and stored potatoes showed a steady decline in vitamin C content from 0.30 mg. per gm. at the end of August to 0.08 mg. per gm. in January. The vitamin C content of King Edward VII was consistently higher than that of the other varieties from August to December.

Karikka *et al.* (*21*) observed varietal differences in the ascorbic acid content of potatoes grown in different localities in New York State in three seasons. Katahdin and Houma gave high values in all three years: Chippewa tended to be low; Irish Cobbler, Warba, and Sebago were intermediate; and the results for Earlaine and Green Mountain were inconsistent. Ascorbic acid content of potatoes grown in different locations showed marked variation. The factors involved in this variability are not known. Neither soil reaction, nor amount of nitrogen, phosphorus, and potassium in the fertilizer, nor the addition of minor elements had a consistent influence on the ascorbic acid content of potatoes. Losses of ascorbic acid tended to occur more slowly in potatoes stored at 50° F. than in those stored at 40°. Approximately two-thirds of the ascorbic acid content of the raw tuber remained in the boiled potato.

Florida Variety Tests

Eddins *et al.* (*8*) reported some of the results of potato variety tests at Hastings, Florida. Sebago, Sequoia, and Pontiac, which proved to be more resistant to freezing injury in the early stages of growth and more drought resistant than eleven other varieties, produced the best yields for seven years. Sebago and Pontiac yielded about one-third more U. S. No. 1 tubers per acre than Katahdin, whereas Sequoia exceeded the yield of the latter by approximately fifty per cent. Sebago and Katahdin have supplanted almost completely the old standard variety Spaulding Rose.

New Varieties

Blodgett and Stevenson (*4*) described three new scab-resistant varieties Ontario, Seneca, and Cayuga. Ontario gave the highest yields of the three. It is highly scab-resistant and also has some resistance to late blight and fusarium wilt. It has fair cooking quality but is not so high in specific gravity as Cayuga. The latter was comparable in yield to Rural and Sebago. Like Ontario, it is highly scab-resistant and has some resistance to late blight and fusarium wilt. It has high specific gravity, cooks white and mealy, and remains white after cooking. Seneca is intermediate in ripening between Cayuga and Ontario. It

has some resistance to late blight and wilt but is not so resistant to wilt as Ontario.

Riedl *et al.* (*31*) described the Teton potato, a new variety resistant to ring rot. This variety has shown a high degree of resistance to ring rot over a period of years in Wyoming and Maine. It produced satisfactory yields and cooking quality in tests in both states. It is not immune to ring rot but should be valuable in districts where ring rot is a serious menace to potato production.

Clark (*7*) described the Calrose potato, a new variety possessing resistance to late blight. It is a high-yielding variety that has proved to be well adapted to environmental conditions in California. It produces an abundant set of tubers that are long, smooth, and attractive in appearance. It requires a relatively long period of growth, which should enable it to supplement other varieties in extending the length of the harvesting and marketing periods where this would be desirable.

Edmundson *et al.* (*9*) described the Pawnee potato. It was a selection from a cross between Rural New Yorker No. 2 and Katahdin and is believed to be a valuable medium-early variety for certain districts.

Bushnell *et al.* (*5*) described the Erie as a new high-yielding variety adapted to conditions in Ohio.

Jehle and Stevenson (*20*) described the Potomac variety whose parentage is Rural New Yorker x Katahdin. It possesses good baking quality and has moderate vine and tuber resistance to late blight, and to injury by flea beetles and leafhoppers.

Wheeler *et al.* (*39*) described the Menominee potato, a new variety resistant to common scab and late blight. It is a selection from a cross of Richter's Jubel and seedling 44537. Menominee is highly resistant to scab and moderately resistant to late blight. If planted early in Michigan it produces high yields of tubers having good cooking quality. It is scab-resistant in Maine where it was first produced and tested but has not been promising except for its scab resistance.

Reddick and Peterson (*30*) described the Empire, a blight-resistant variety. This variety was produced as the result of a series of crosses made for the purpose of producing new commercial varieties which could combine the immunity to blight of the species ***Solanum demissum,*** Lindley with the desirable horticultural and culinary characteristics of the commercial varieties commonly grown in northeastern United States.

Empire is adapted to most parts of New York, but it is too late in maturity to be at its best on Long Island. It withstood severe inoculation tests in the greenhouse but was found not to be absolutely immune in the field. The authors assume that the resistance of Empire ultimately may break down and that the same assumption will have

to be made in the case of any introduction of a blight-proof potato until long experience indicates that a breakdown does not occur.

It is stated in THE POTATO WORLD dated January 1, 1946, that Dr. Donald Reddick of the New York (Cornell) Agricultural Experiment Station had named five blight-resistant varieties Ashworth, Chenango, Essex, Placid, and Virgil.

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NET RETURNS FROM POTATO FERTILIZERS

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Before a successful business man comes to a decision about an enterprise under consideration, he invariably wants to know two things —the cost of the investment and the probable gross returns. Given these, he can usually estimate his expected net returns or margin of

[1]Division of Fruits and Vegetable Crops and Diseases.

profit. That is one of the principal reasons he is a successful business man. It is not necessary to remind potato growers that they are business men but it does seem timely to extend a word of caution lest they forget momentarily that the only correct way to figure the relative profit between different rates of fertilizer application is from the returns "beyond" the cost of the fertilizer. It is understood, of course, that from these returns "beyond" the cost of fertilizer there must be deducted all other costs of production in order to arrive at the real net profits per acre, but we are not specifically concerned with these here.

Profits Based on Net Returns

Now this may appear to be a very elementary statement obvious to every one intelligent enough to grow potatoes, but under the stress of the period of unlimited production and guaranteed price from which we are at present emerging, this fundamental point in production economy can easily be overlooked. Furthermore, there are two misconceptions that I wish to discuss which help to make it easy for us to overlook it. For instance, those advocating the plowing under of large amounts of fertilizer in addition to the amounts applied at planting time, frequently compare the results obtained on the basis of gross returns without giving due consideration to the cost of the additional fertilizer plowed under. This, of course, is an error. Whether this charge for fertilizer should be made against the first crop or spread over succeeding crops is a question that can only be answered by experiments conducted on the same land for a period of years, but one thing is certain, it should be charged against some crop or crops.

Law of Diminishing Returns

Another misconception, and this one can be very serious for some potato growers, stems from statements such as these: "For every dollar spent for fertilizer there is a gross return of $3.60" (2), or as recently reported from one southern potato-growing state, $1.50 to $9.00 (1). These statements can be misleading in two ways. In the first place, they imply that the gross returns from fertilizer use is linear, that is, if these returns are plotted they will form a straight line, as illustrated by the dotted line A in figure 1. Actually, however, these returns do not form a straight line, but a curved line as shown in the illustration. This particular curved line represents the estimated gross returns based on 7-year average yields of No. 1 potatoes[1] from fertilizer rate experiments conducted on the North Shore of Long Island and with the growers' own fertilizer, which at that

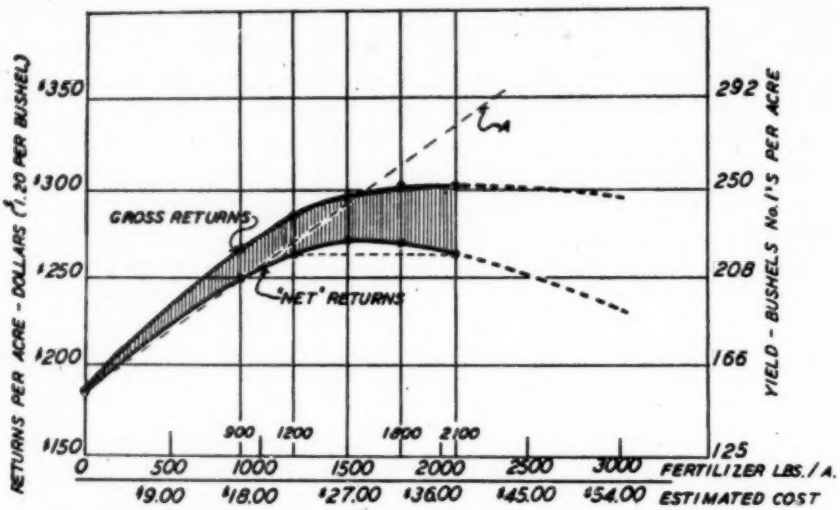

FIGURE 1. Curves showing gross returns, and net returns per acre "beyond" the cost of potato fertilizer applied at different rates per acre. A: theoretical linear relationship $1.00 for fertilizer (Long Island data) produces $4.06 average gross returns.

time was a 4-8-5 mixture. The only part of this curve that would approach the theoretical straight line implied by the foregoing statements obviously corresponds to rates of application too low for the economic production of potatoes on Long Island.

You may be wondering why the true relationship between fertilizer use and the returns therefrom is described by a curved line and not a straight one. There are two reasons: In the first place, the productiveness of land is not unlimited. It is true, of course, that the maximum production can vary from farm to farm and even from field to field with the kind of land, the manner of treatment, the weather conditions, and the ability of the grower, but strive as you may, under any given set of conditions, there will always be a limit to the productive capacity of any land. For these reasons a "net" returns curve should be obtained from every farm or field, if possible.[2]

The upper yield or gross returns curve in figure 1 illustrates what the writer has chosen to call "The Law of Diminishing Need." The principle that makes this *biological law* operative is widespread in

[1]These yields were obtained by Dr. Bailey E. Brown, formerly Senior Biochemist, Bureau of Plant Industry, Soils, and Agricultural Engineering, Agricultural Research Administration, U. S. Department of Agriculture.

[2]The writer has prepared a set of instructions which describe in detail a method for conducting a simple fertilizer rate test on potatoes, the results of which can be used to plot a "net" returns curve. If you are interested write to him for a copy.

its application and is familiar to nearly every chemist and undoubtedly is recognized by many agronomists as well. It operates with increasing applications of single elements, such as nitrogen, phosphorus, and potash, as well as with complete fertilizers. This being true, the second reason follows inevitably, illustrated by the second curve,—under these conditions the *physical law* of diminishing returns, as illustrated by the "net" returns curve, is bound to operate. These are two laws that will never be repealed despite the tacit assumption of those who imply the straight line relationship illustrated in figure 1.

The Fallacy of Gross Returns

As business men and potato growers, however, your real interest lies not so much in gross returns as in net returns, in this particular case, returns "beyond" the cost of fertilizer. To illustrate the relationship that can be expected between gross returns and net returns a curve has been drawn indicating the returns "beyond" the cost of fertilizer with the selling price of potatoes estimated at $1.20 per bushel and the cost of fertilizer at $36.00 per ton. Obviously, these prices are estimates, but they will serve the present purpose. If they are altered either way, only the positions of the two curves will be mainly affected; there will be little effect on their shape. The important thing to notice about these two curves is the steadily increasing size of the shaded area between them, which represents the difference between gross returns and net returns "beyond" the cost of fertilizer, or its actual cost.

As will often be the case, the maximum net returns from fertilizer use will not necessarily come at the point of highest gross returns. After the point of highest net returns "beyond" the cost of fertilizer has been reached, which, for the fields under consideration correspond from 1500 to 1800 pounds per acre, the decline is steady even though the gross returns may have slightly increased. But it should be noted further, and this is important, that neither gross returns nor net returns follow a straight line for current Long Island applications as might be inferred from statements that each dollar spent for fertilizer will yield a gross return of a stipulated amount.

The Switch from Unlimited to Limited Production

These economic considerations, as simple as they may seem, are not always fully recognized during a period of unlimited production and guaranteed price. During a period of limited production, however,

with production quotas based on acres, as reflected by the goal requirements of the 1947 potato price support program, emphasis must be switched from quantity production to economic production.

About the only feasible way to limit total production while maintaining the maximum economic yield is to limit acreage. In this way, there is a maximum return above the cost of fertilizer, the land is used economically, and some land is released for other cash crops or preferably for soil-building crops. In this regard, it will be of interest to note from figure 1 that the particular fields studied showed just as large a net return from 1200 pounds of fertilizer as from 2100 pounds and 5.5 per cent fewer potatoes to handle.

The foregoing economic discussion of fertilizer use could be summed up in the statement sometimes made by potato growers (usually over 50 years old) who declare that they are not growing their crop as well as they know how because they couldn't afford to. In this statement, usually intended for a joke, there is a good deal of economic wisdom, provided they are sure that they have reached the point of maximum net returns on their farms.

From the study of curves similar to the one presented, which would show the net returns "beyond" the cost of fertilizer for any particular field or farm, much information can be obtained which will help to make a good potato grower a successful business man. To illustrate, the 7-year average yields used in the present discussion were obtained without irrigation. It would be of interest and of considerable value to obtain a similar curve while using irrigation and larger amounts of fertilizer than customary. In this way it would be possible to evaluate the efficiency and economy of both fertilizer and irrigation in a way that would have real meaning to a potato grower—his net returns per acre.

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TIME OF INFECTION AND ACCUMULATIVE EFFECT OF RHIZOCTONIA ON SUCCESSIVE CROPS OF POTATOES[1]

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INTRODUCTION

Rhizoctonia disease of potatoes is caused by *Rhizoctonia solani* Kuhn (*Corticium vagum* Bourd. and Galz.) and it infects potato plants either through soil-borne mycelium or through mycelium produced from sclerotia present in the soil or on the potato tubers. Practically all underground parts of potato plants are subject to infection with *Rhizoctonia,* especially the underground stems, stolons, and tubers, and to some extent potato roots.

Potatoes are usually planted in Montana some time in May and the heaviest rainfall ordinarily occurs in June, when temperatures are also quite low. During this period of unfavorable weather conditions potato plants grow slowly and they are usually quite susceptible to attack by *Rhizoctonia.* Consequently, in certain years *Rhizoctonia* causes a considerable amount of damage to the potato crop in Montana. Most of the commercial growers in Montana treat their seed potatoes either with mercuric chloride or formaldehyde, so the danger of introducing infection in the soil with the tubers is rather slight. Severe outbreaks of this disease which often occur even in fields planted with treated potatoes, indicate that soil-borne *Rhizoctonia* probably is a great factor in the occurrence of this disease in the field.

The purpose of this investigation was to determine on land, not previously cropped to potatoes, the time and degree of infection with soil-borne *Rhizoctonia* of all underground parts of potato plants under conditions of continuous cultivation. The accumulative effect of inoculum in this soil on the severity of the disease in subsequent years was also investigated.

MATERIALS AND METHODS

Bliss Triumph potatoes were planted during the years 1936-1940 in the same ⅛ of an acre plot at the Huntley Branch Station, Huntley, Montana. The soil of this plot was of a clay-loam type with a

[1]Contribution from Montana State College, Agricultural Experiment Station Paper No. 193 Journal Series.

pH 7.8. No potatoes had been grown in this soil for at least twenty-five years. Preceding crops beginning with 1930 and ending with 1935 were as follows: sweet clover, corn, sugar beets, wheat (sweet clover), sweet clover, and corn. Moisture was supplied by irrigation, so during the growing season the soil always had a sufficient amount of moisture.

Certified potatoes practically free from infection with *Rhizoctonia* were planted. These potatoes were treated with formaldehyde, cut, and planted with a single row picker planter in rows three feet apart. Potatoes were usually planted some time in May and harvested during the latter part of September.

Examination of all underground parts of potato plants for infection with *Rhizoctonia* was made several times during the growing season and in addition the potato tubers were examined after harvest.

Potato stems, stolons, and roots were examined for *Rhizoctonia* lesions, and tubers for the presence of sclerotia. In 1937 four examinations of potato plants were made during the growing season and in the remaining years only three. At each examination, 30 potato hills

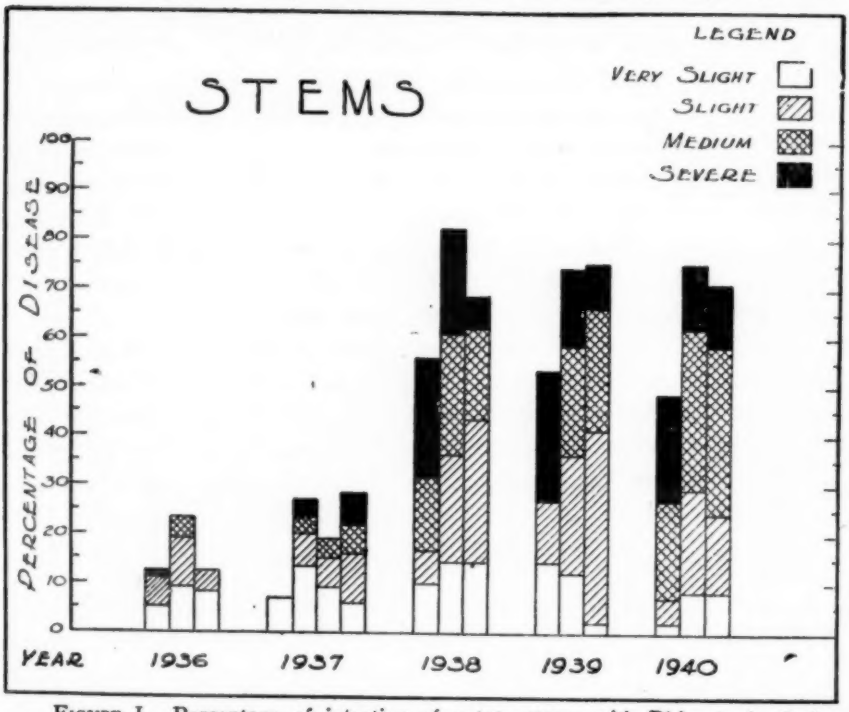

FIGURE I. Percentage of infection of potato stems with Rhizoctonia during 1936 to 1940.

were dug, and the underground parts of the potato plants were washed and carefully examined for the amount of infection with *Rhizoctonia*. In the fall at harvest time, a random sample of 100 pounds of potatoes was collected in this plot and graded for the presence of sclerotia on the tubers. The degree of infection of the different parts of potato plants with *Rhizoctonia* was recorded as: very slight, slight, medium, and severe.

Results

Potato Stems

The percentage of infection of underground parts of potato stems with *Rhizoctonia* was rather low (Figure 1) in 1936 and 1937 (maximum of 23.0 and 28.0 per cent respectively) and high in the remaining years (maximum of 82.0, 75.0, and 75.0 per cent respectively for 1938, 1939, and 1940). The amount of infection of potato stems in all years was usually the lowest on the first date of reading. The second reading in most of the year (1936, 1938, and 1940) showed a somewhat greater infection of stems with *Rhizoctonia* than the last one. This situation probably was due to the fact that the plants which

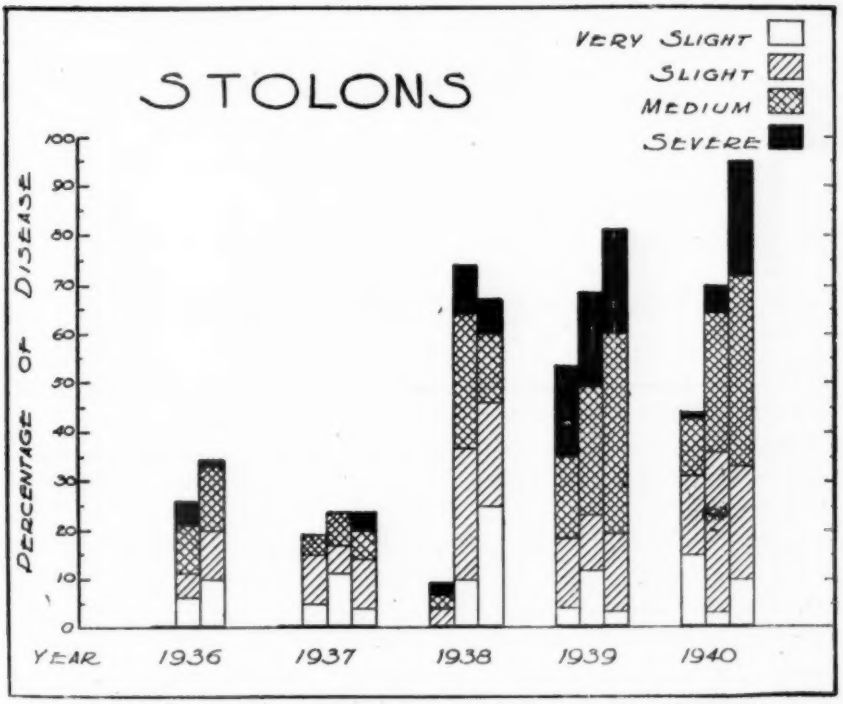

Figure 2. Percentage of infection of potato stolons with Rhizoctonia during 1936 to 1940.

were already severely infected with *Rhizoctonia* on the second reading perished before the last reading was taken. The proportional degree of infection, in general, was rather slight in 1936 and 1937, but in remaining years it increased considerably in its intensity. It appears that after two years of growing potatoes in this plot, the amount of infection of potato stems with *Rhizoctonia* reached its maximum and remained at about the same level during the last three years of this experiment.

Potato Stolons

The percentage of infection of potato stolons (Figure 2) with *Rhizoctonia* showed about the same trend as that of the stems. In the

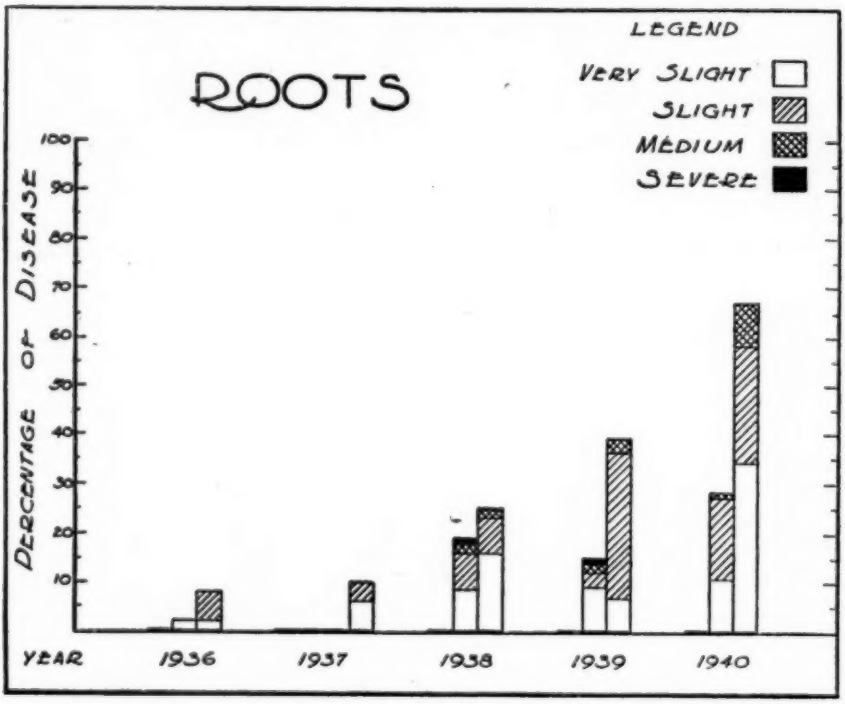

Figure 3. Percentage of infection of potato roots with Rhizoctonia during 1936 to 1940.

years of 1936 and 1937 the stolons had the lowest percentage of infection (maximum of 34.0 and 23.0 per cent respectively), but in the years 1938-1940 infection began to increase rapidly and in 1940 most of the potato stolons (95.0 per cent) showed infection. The lowest infection of potato stolons in all years was on the first date of reading and the highest, with the exception of 1938, on the last date of read-

ing. The proportional degree of infection of potato stolons with *Rhizoctonia* gradually increased toward the end of the experiment.

In general, these results show that the greatest increase in total infection of potato stolons with *Rhizoctonia* occurred in the third year of the experiment, after which infection also continued to increase, although only at a low rate, until the end of this experiment.

Potato Roots

The percentage of infection of potato roots with *Rhizoctonia* (Figure 3) was low in 1936 and 1937 (maximum of 8.0 and 10.0 per

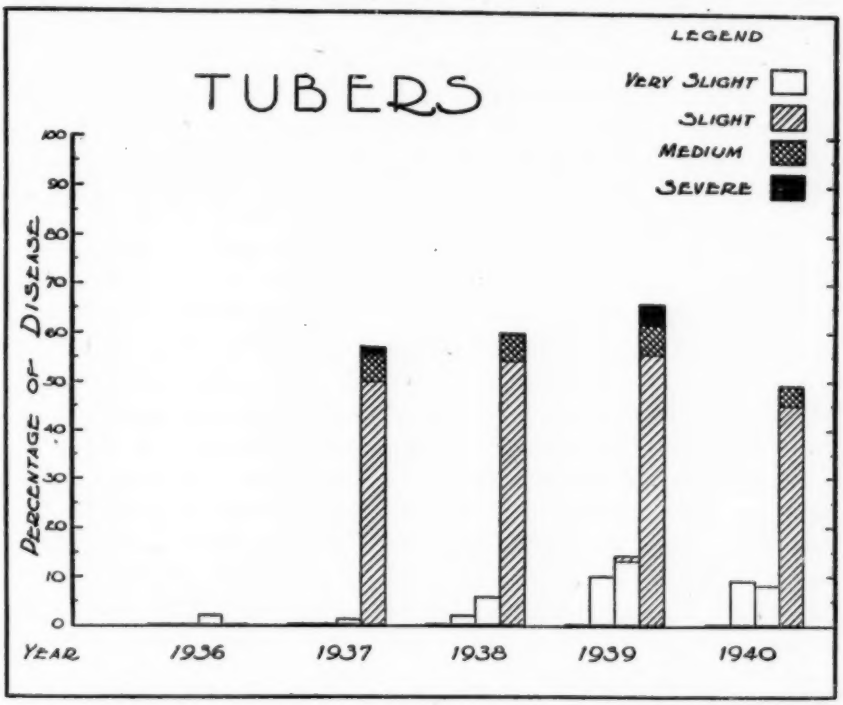

FIGURE 4. Percentage of infecton of potato tubers with Rhizoctonia during 1936 to 1940.

cent respectively). Beginning with 1938 the infection began to show a marked increase and reached 67.0 per cent of the total potato roots in 1940. Roots were usually free from infection on the first date of reading and the infection usually increased toward the fall. Infection of potato roots with *Rhizoctonia* was slight throughout all five years of the study, although its intensity was somewhat greater during the last two years of the experiment.

In general, these results show that infection of potato roots with *Rhizoctonia* continued gradually to increase during all five years of

the experiment and that the greatest relative increase occurred after the first two years.

Potato Tubers

In the first year of the experiment, the infection of potato tubers with sclerotia of *Rhizoctonia* was only two per cent (Figure 4). Potato tubers in all the remaining years showed a rather high and uniform infection with sclerotia, with the maximum of 66.0 per cent of infected tubers in 1939. The infection of tubers with sclerotia remained low during the growing period and greatly increased just before digging time. The degree of infection of potato tubers with sclerotia in all these years remained mainly slight in nature.

In general, these results show that the greatest increase in infection of potato tubers with *Rhizoctonia* occurred in the second year of the experiment. After this the percentage and severity of infection remained about the same for all remaining years of the experiment. The amount of infection of potato tubers in 1940 was even somewhat lower than in the three preceding years.

Discussion

Potatoes had not been grown in the experimental plot for 25 years preceding 1936 when this investigation was started. Our records indicate that it is quite possible that potatoes had never been grown in this soil. During the period of 25 years prior to this experiment wheat, sweet clover, corn, and sugar beets were grown in this soil.

Apparently there were only very small amounts of soil-borne *Rhizoctonia* present in this soil at the time the first crop of potatoes was planted in 1936. At least during the first two years potato stems, stolons, and roots showed only a small percentage of infection, which considerably increased during the third and including the fifth year of the experiment. A similar increase in infection of tubers also occurred during the second year.

These results show that a sufficient amount of soil-borne *Rhizoctonia* was present in this soil even without cropping it to potatoes to be able to start initial infection. It is also apparent that it takes only 1 or 2 years for the *Rhizoctonia* disease to increase in the soil to become an economic factor in the growing of potatoes. These results emphasize the importance of soil-borne *Rhizoctonia* in producing infection on potato plants planted with disinfected tubers.

In evaluating the susceptibility of different parts of potato plants toward infection with *Rhizoctonia,* it appears that potato tubers are very susceptible to this fungus. The tubers showed infection only with

sclerotia, and this infection appeared in considerable amount only immediately preceding the harvest. The stems and stolons appear to be equally susceptible to this fungus and more so than the roots, which showed considerable resistance to infection with *Rhizoctonia*.

In controlling this disease, cultural practices such as planting crops resistant to *Rhizoctonia* and growing potatoes only once in several years will prevent the accumulation of *Rhizoctonia* in the soil. Potato tubers which are used for planting should be disinfected to prevent introduction of new inoculum in the soil.

Summary

1. Treated potato tubers were planted in five successive years in soil where potatoes apparently never were grown before, to study the infection of potato plants with *Rhizoctonia*.

2. Potato tubers had only a very small percentage of infection with *Rhizoctonia* in the first year and this infection increased considerably the second year and remained until the end of this investigation.

3. Potato stems, stolons, and roots showed a small percentage of infection during the first two years and this infection increased considerably for stems and stolons and moderately for roots during the third year of the study and remained at the same level until the end of the investigation.

4. Potato stems, stolons, and tubers are very susceptible and potato roots are somewhat resistant to infection with *Rhizoctonia*.

5. It appears that a period of only one or two years is necessary under favorable conditions to build up the *Rhizoctonia* inoculum in the soil to produce maximum infection on potatoes.

6. In controlling this disease it appears it is necessary besides treating tubers, to use long rotations.

SECTIONAL NOTES

ALABAMA

Alabama has an increased allotment for Irish potatoes under the 1948 support program. Present indications seem to point to a reduction rather than an increase in planting. A good estimate, at this time, would be about 15,000 acres for our early Commercial section or approximately 2,000 acres less will be planted during the season of 1948. As the deal gets started interest will naturally increase and additional acres may be planted. Our ratio of Triumphs and Sebago will be nearly the same as last year,—⅔ Triumphs and ⅓ Sebago. The Triumphs will be produced for early shipment and the Sebago for later shipments.

This will be an expensive crop to plant, probably the most expensive in the history of our deal. Seed will sell at or near the $5.00 per hundred mark. Fertilizer has also increased in price. It will cost our growers more than $100.00 per acre by the time the crop emerges.

Most of the growers are preparing to control Late Blight with dust and there will be considerable spraying with Dithane. There seems to be plenty of material on hand to take care of this problem when it does arise. (Jan. 5).—FRANK E. GARRETT.

COLORADO

Shipments from Colorado have remained light this past week. However, the demand is reported to have shown some slight improvement. The San Luis Valley has shipped to date about 5,500 carloads, which leaves a balance of about 3,000 carloads to be shipped from that area.

Some seed shipments are beginning to move both into the state and out of state. Seed shipments or re-certification have come into the state from Prince Edward Islands and North Dakota. Out-of-state shipments have been largely to Texas and Arizona, to be planted for the early market.

The winter test plantings in both Texas and California have now been completed. Disease readings will be made about the 15th of February. In addition to winter testing in a southern climate, considerable hill and unit indexing is being done in the green house as an aid to foundation growers.

That part of the Western Region Hope-Flanagan Marketing Research studies which are being undertaken by Colorado are getting under way this week in Denver. These pilot studies may extend into other markets next year. At the present time these studies are to determine consumer preferences in regard to size and type of package. Special types of packages containing sizes 2″ to 2½″ and 2½″ to 3″ are being followed through from the packing house to the consumer in retail stores. (Jan. 6).—CECIL W. FRUTCHEY.

FLORIDA

Climatic conditions during December were generally favorable for potatoes in the Homestead area, although wet fields continued to retard planting operations on some farms until the week of the 15th of January. A total of approximately 5,500 acres were planted over a period of 75 days. The crop now growing looks well with prospects of good yields in all fields that were planted during November. These plantings escaped much seed-piece decay.

Some late blight is present in all fields but growers have held it

under control by spraying to the present time. Serpentine leaf miners are less in evidence than was the case last year. (Jan. 10).—G. D. RUEHLE.

MAINE

The Executive Committee of the Aroostook County Farm Bureau in behalf of Maine farmers has requested the Commissioner of Agriculture to institute proceedings that would bring about hearings on a Marketing Agreement. This decision was reached as a result of twenty-eight Triple A meetings in Aroostook County which were attended by 1,632 farmers. The farmers were virtually unanimous that a Marketing Agreement should be considered.

The market continues to hold rather closely to the support price, although there is some optimism concerning the spring market. The government has purchased 4,810 cars of the 17,962 cars shipped to the 7th of January. This indicates that the department has been a big factor in supporting the price.

Several sections of the county have experienced a great deal of field frost in some of their potato stocks. Many of them show frosted ends which is a big headache to some shippers. It is thought that these potatoes have now been fairly well moved from the county.

A campaign to have every farmer plant certified seed is being conducted. The estimate for the Maine crop in 1947 indicates 345 bushels per acre. The average for all varieties for certified seed is 391 bushels to the acre. The difference of 46 bushels gives the campaign some real arguments for every farmer to plant certified seed. If this campaign goes over well it should do much to eliminate ring rot from the county.

Stem-end browning is appearing in a number of varieties. At first many felt that it might be a discoloration caused by killing tops with various materials but a number of lots have been noted which died naturally, so it is apparent that stem-end browning cannot be blamed upon top killing materials.

Aroostook farmers are still interested in continuing price support and members of the Triple A recently indicated that they would be willing to accept another 5 per cent reduction in acreage if all the country would do the same. (Jan. 8).—VERNE C. BEVERLEY.

NEW JERSEY

The Government's plan to cut the New Jersey potato acreage approximately 20 per cent in 1948 has been abandoned according to advice from the P&MA. This is good news to our potato producers since such a cut in many instances would have reduced the individual grower's

acreage to such a point that it would not be economically sound to continue to raise potatoes. Such a request would have forced many growers to disregard government requests and plant in excess of their goals.

The Potato Industry Committee has voted to inform the State P&MA that (1) many growers would voluntarily reduce their acreage in 1948 and leave this acreage in wheat or other crops if the P&MA would guarantee that such a reduction would not be taken into consideration in setting any future goals or acreage allotments. The world is in great need of additional wheat and this action would add materially to the supply.

(2) New Jersey growers are also in favor of the plan abandoned by P&MA last year whereby if the Government had to purchase potatoes to support the price, that such purchases would be made at market prices below the 90 per cent of parity price and that the difference between the purchase price of 90 per cent of parity be paid to the producer. The market price however, would not be allowed to drop below a definite flow price. This plan would reduce the price of potatoes to the consumer in case of an over-supply in the markets at any time which would require the government to support prices.

(3) The brokerage of 8 cents a sack allowed for selling potatoes to the Government is too high and gives the dealer no incentive to try to sell his potatoes to the trade and should be reduced to 5 cents.

The Annual Meeting of the New Jersey State Potato Association was in Trenton January 29 and 30, during Farmers' Week. Many important topics were discussed, including the future of the industry, and government support, the status of the Golden Nematode, marketing, wireworm control, spray and dust materials, and general cultural topics. (Jan. 17).—J. C. CAMPBELL.

NEW YORK

Since the 1st of January, growers have responded to the increase in Government support price much better than they did in December. Most generally in up-state New York they are at support levels.

There is beginning to be a lot of interest in seed potatoes for spring shipment. Growers have apparently completed and planned for the 1948 season and it would appear that they expect to plant about the same as last year.

There is very little interest in preparing for Post-Stegall among some large growers. There seems to be a feeling for regulations of acreage with support price coupled with some form of marketing agreement. Perhaps the majority of growers are not in favor of any program.

More than a thousand potato growers attended the Annual meeting

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of the Empire State Potato Club in Syracuse on the 8th and 9th of January, and many problems of practical nature were discussed. Features of the Convention were sessioned with potato specialists at the College exhibit, big Trade Shows, and forum discussions on current subjects of interest to potato growers were held. (Jan. 7).—H. J. EVANS.

TEXAS

The spring crop of potatoes in the Rio Grande Valley will be about two weeks earlier than normal. Rains came the early part of December and provided sufficient moisture for planting. Rain always provides more perfect moisture than irrigation, so our stands should be better than normal. We have estimated that the acreage to be planted in this section for spring harvest will be 11,500 acres. (Jan. 9).—CLEVE H. TANDY.

PROVINCE OF ONTARIO

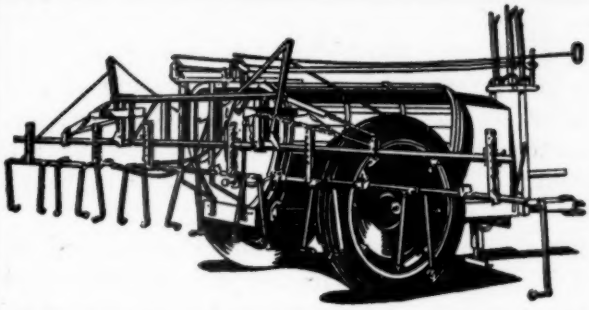
Two hundred and seventy-five potato growers in Ontario have completed their activities in sixteen 500-bushel Potato Clubs, organized by various county and district branches of the Ontario Crop Improvement Association in 1947. The average yield for all these competitors, as uniformly calculated after carefully taken measurements and weights, is 392 bushels per acre, which is 14 bushels below last year's provincial average.

In the sixteen competitions, 123 competitors produced yields of more than 400 bushels per acre; 41 reached and passed the objective of 500 bushels; twelve exceeded 600 bushels and one grower broke previous records with his estimated yield of 718 bushels per acre.

Several clubs featured quality per acre and substantial prizes were also awarded for bushel exhibits and the condition of potatoes in storage. Potato growers banquets were held in eleven rural centres, where outstanding speakers were heard, presentation of prizes made and entertainment provided. Every grower whose yield was 500 bushels or more per acre received a certificate of merit from the Ontario Crop Improvement Association.

At a recent meeting of the Potato Committee, Ontario Crop Improvement Association, a decision was made to hold a full day's Provincial potato growers meeting at Toronto on Monday, the 9th of February. Arrangements were also made to hold a potato grower's luncheon on the same day. The program plans include several outstanding speakers and discussion periods on timely topics of interest to potato growers.

The committee heard reports on activities during the past season on the following topics: Spray and dust tests in Eastern and Western On-



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Harry E. Umphrey, *President*

tario; bacterial ring rot survey; 500 bushel clubs in Ontario; costs of production; grades and enforcement of grading regulations; storage holdings; market prospects and exhibition results. There was further discussion relative to the establishment of seed producing areas, testing and licensing of varieties and other subjects of importance to the potato industry.

Members of the Committee are: Howard Harper, Goodwood, *Chairman;* J. Nicol Wilson, Alliston; Hill Simpson, Bellwood; Edgar Hewitt, Simcoe; Ross Gregory, Strathroy; Lloyd Logan, Kemptville; Charles McQuire, Colborne; E. G. Snyder, Preston; George Hackett, Cochrane; A. V. Mason, Dundas, with R. E. Goodin, Toronto as secretary. (Jan. 2).—R. E. Goodin.

NEWS ITEMS

C. L. Fitch

I. *The "Clean" Cobbler Supply of North America*

Third survey at five-year intervals

In 1937, I visited Prince Edward Island. That year Mr. Peppin had 1,800 of their little farms, with Cobbler fields which had had no visible virus found in them from 5 to 20 years or more, according to his certification inspectors; and there were a few such farms in other provinces of Canada.

In 1942, there were only 5 such farms on Prince Edward Island. The wish to get into the Katahdin, Chippewa, and Sebago seed trade had coincided with a sizeable peach aphid epidemic!

In September of this year, I was in Prince Edward Island, again. Many of Mr. Peppin's Cobbler growers had quit the leaf-roll carriers, D D T had come into the picture, and he had again 342 farms with clean Cobblers. As we complete this survey, we may find other such farms in Canada and a few in U. S. A. besides those mentioned below.

In the Lake-of-the-Woods and the Iron Range areas of Minnesota, and in S. W. Colorado, there were at least 10 to 40 farms where Cobblers have been clean for a score of years. Some clean Green Mountains have also been produced on these farms.

We thoroughly believe in the tuber unit and seed plot method for maintaining health and getting along with the stocks that are available; but we regard the purchase of "clean" seed as a superior part of an effective system wherever and whenever such seed is available.

Presented at the Annual Meeting of the Potato Association of America, Chicago, Dec. 28, 1947.

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II. *A Case Appearing to be Stem Scald of Potatoes*

Veril Baldwin of Jackson, Michigan, in 1947, had a large field of Katahdins and Chippewas, in which 1 row of each sprayer width received no bordeaux. This resulted, by the 1st of August, in a serious dropping of leaves caused by late blight.

Immediately thereafter came the intense heat and drought of August 1947. The potato vines fell over and the tips assumed perpendicular positions. On many plants a large percentage of the recumbent part, a few inches from emergence from the ground, where facing the afternoon sun, were found a few weeks later to be rotted off up to the erect and partly shaded portions. The stubs of the stems were perfectly sound. On and in them, there was no sign of fungous or bacterial activity. The erect and partly leaved portion of the stems remained green after the stem below appeared completely decayed. Either conductive tissues had persisted, or the tips drew upon the wet and rotted stems as from a vase, or both.

A number of plant pathologists, from several departments, reported they had never seen this phenomenon. The growers in Indiana were the only ones who had seen it. I had never seen it and many specialists may never observe it. A college representative from East Lansing declared the trouble to be sunscald of stems. We are inclined to believe his opinion to be correct.

In our studies of frost injury, we proved that potato stems act as important conductors of ground warmth. In this case the cool ground apparently protected the stems from scald.

The yield of that field was considerably reduced. The losses from this trouble may never justify research studies of the matter.

III. *Plans for Large Expansion of Potato Breeding*

The National Potato and Onion Committee was formed 19 years ago, following a request from William Stuart, for the purpose of obtaining large appropriations for potato breeding. It has been my privilege to be the executive officer of that committee. It has functioned frequently, as needed, and several members at a time have appeared before appropriations committees at Washington. This committee held its first regular meeting at Mason City, Iowa, on the 9th of December. Nineteen members from 15 states were present. Dr. Henry A. Jones came from Washington for the meeting. The breeders from all nearby states were invited, but the invitations went through too many hands and therefore were too late so that only the Wisconsin and the Iowa stations sent representatives. They reported, barring salaries, that field trials are the largest expense of potato breeding.

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So far about $1,000,000 of federal money and $2,000,000 of state money have been spent for these great projects. Onion breeding has already paid large commercial profits, and will soon make vast profits above the cost of the double project. Potato breeding to date has achieved no main commercial objective. It seems desirable to increase to a greater extent the potato seedlings produced by the states; and to uphold further the hands of our successful breeders of onions. This winter the committee desires to increase these federal appropriations from $65,000 per year to $125,000. Discussions are under way for a plan that may succeed not only with congress this winter, but also in the production of 3 to 5 times as many seedlings. This plan may take the form of the federal government bearing all field costs for all approved agencies.

"SOME OBSERVATIONS ON POTATO PRODUCTION IN CUBA"

DR. MANUEL A. TAMARGO[1]

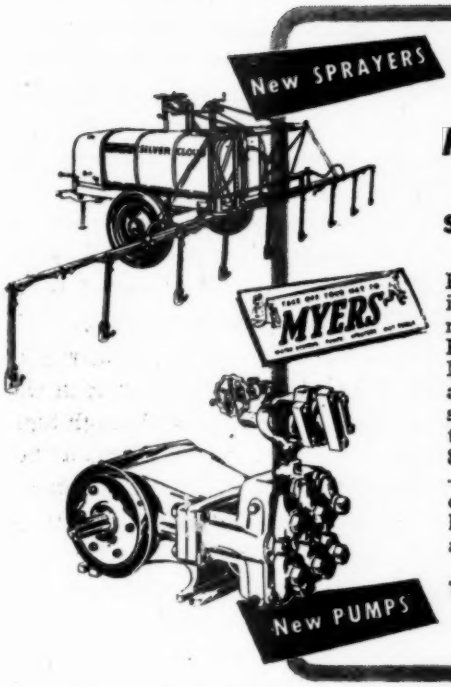
Ministry of Agriculture, Havana, Cuba

For many years Cuba has been importing certified seed from abroad for planting. Years ago, a few growers used home grown seed (small sizes) from the last spring crop for planting in early September. When the weather is favorable, planting starts about the middle of September. Immature seed has been troubling the growers for this planting, in the form of seed piece decay. Seed that has not completed the rest period is planted and irrigation water and rain often rot these seed pieces before the plants emerge from the ground. The best recommendation that can be given to the Cuban growers is, not to plant so early and, if necessary, plant seed on top of the drills and not in the furrow, using whole seed of small size or seed well suberized, and for the exporters to send to Cuba only the potato seed that has completed its rest period.

One of the main problems that affect potato production in Cuba is the late blight. Late blight, as a rule, is present in potato fields during December and January and, from that date, is prevalent until April.

Early digging at the point of production in foreign countries and the demand for certified seed for early planting by Cuban growers are responsible, not only for the arrival of seed which has not completed the rest period, but it may also be almost impossible for foreign inspectors

[1]Head of the Grain and Root Crop Bureau.



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to detect late blight on shipments moving to Cuba, which perhaps have been infected with blight during the harvesting operation.

It would seem to be that, if seed is held in foreign countries for a certain length of time,—if the seed is infected—that the symptoms of the disease will have sufficient time to "show up" and can be easily detected by foreign agricultural authorities before it is shipped to Cuba. By doing this, they will save a lot of money for shippers as well as for the Cuban growers.

The summer temperature in Cuba sometimes rises above 40° C (104° F), and this temperature is very common during July and August. It is a generally accepted fact that *Phytophthora infestans* cannot withstand a temperature of 40° C (104° F) for more than four hours.

From the above, it seems very reasonable to suppose that, whenever an epidemic occurs in Cuba, one should look for the origin of it in the seed received, as the chances of infection by spores coming through high altitude air currents, which might blow from other infected areas as far away as Hastings or Homestead in Florida, U. S. A., are very remote.

The growing season in Cuba is from September to the middle of April. During these months, the mean temperature is 22°C (73.6 F.). This is low enough to make a good crop of potatoes, which, according to Cuban growers, is 10 to 1 (one bag of seed produces a yield of 10 bags). According to planting distance and the size of seed piece most generally used,—which is 36 inches between rows and 12 inches between hills and a seed piece of one ounce,—an acre will require 963 pounds of seed and will produce a yield of 153 bushels of potatoes, which is at the rate of 10 to 1. The length of day for that period of time is about 10.8 hours.

Although Cuba is considered a tropical country, and the rainfall averages up to 48.25 inches, the monthly average for September and October is 6 inches, and the average for the rest of the growing season is 1.5 inches, which includes the months of November, December, January, February, and March. These facts have caused the growers to use irrigation on their fields. Commercial fertilizers are generally used and many growers apply Bordeaux mixture or dust for the control of Blight.

Seed treatment is very seldom used. This may account for the increase of potato scab damage present in some territories, as the soil in which potatoes are grown belong to the Matanzas clay family (classification of Allyson and Bennett), which has a pH. value between 6.5 and 7.5.

Certified seed most commonly used comes from: Canada; Long Island, New York; Nebraska; North Dakota; Maine; Minnesota; and South Dakota.

Meeting the Goal

Again American Potato growers are faced with a high production goal—2,352,000 acres in 1948 as against 2,239,000 acres in 1947. Again they will have need for the findings of agricultural research on the most efficient and economical cultural and harvesting practices for large yields of high quality. For instance, to grow a good crop of No. 1's, soil and fertilizer should supply at least 200 lbs. of available potash (actual K_2O) per acre.

Consult your official agricultural adviser or experiment station about the amount of plant food needed to grow your crops and how much your soil will supply. If you have not had your soils tested, make plans to have this done before the planting season. The information to be gained from these tests will be a helpful guide in your purchase of fertilizers.

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